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Welcome to Issue 54

January 2000

The NASA Science Information Systems Newsletter (SISN) is prepared for the Office of Space Science (OSS), Science Information Systems (SIS) Program through an agreement with the Jet Propulsion Laboratory. The newsletter, which has been an ongoing task for over ten years, is a forum for the space science and applications research community to report research and development activities, outreach activities, and technology transference. SISN offers a venue for articles that are not likely to appear elsewhere and provides the opportunity for information exchange within the science community, as well as a platform for accomplishments by that community. Related articles from other programs and agencies are also published.

Questions or comments regarding this newsletter task may be emailed to Sandi Beck at <sandi.beck@jpl.nasa.gov>.

Credits: Design and format by Editor, Sandi Beck. Graphics design, animation, and rollovers by Scott Brenneisen, XTREME GRAFX. Also, thanks over the years to Calvin Yee, formerly of Telos Information Systems, Doug Steinwand, formerly of JPL, and the JPL documentation staff.

Science Directed Spacecraft Autonomy for Mars Missions

Paul Stolorz, Bob Crippen, Ron Blom,and Tim Stough, Jet Propulsion Laboratory

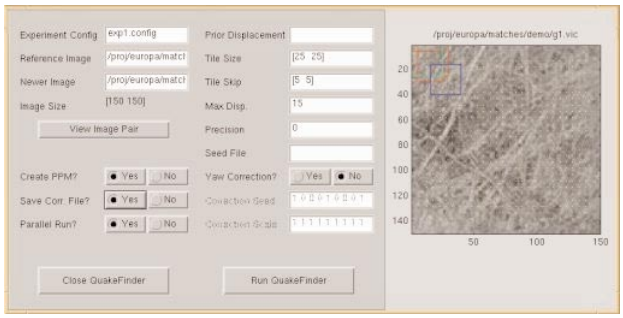
The rapidly growing field of remote sensing is beginning to supply massive amounts of high resolution imagery of the earth and other planets. Within the earth sciences, parallel supercomputers have always played a prominent role in the visualization of this imagery, and in other image processing applications designed to enhance and display the information obtained. Researchers at NASA are now turning their attention to the implementation of powerful new analysis tools for satellite imagery on MPP's, in order to obtain direct information about important physical processes that until now has often remained buried within these large datasets.

One obvious process of great physical interest is the motion of surface faults during the course of an earthquake. The motion mapping software applies machine learning techniques to the measurement of very small ground displacements due to earthquake activity by carefully comparing two high resolution satellite images of a fault-laden area (one image taken before the quake, and one taken after it). The chief drawback of the procedure is its enormous computational demands. When implemented on workstations, the method is capable of providing ground displacements for a few hundred pixel locations scattered throughout an image. But modern satellites generate images containing millions of pixels. We would really like to make a high resolution ground-displacement "map", showing the movement of every single pixel during an earthquake. This same system can be used to analyze any images where small surface motions are suspected.

The system could be deployed onboard a spacecraft to select regions of interest to be imaged in higher resolution. Given a library of reference images from previous missions, future missions could apply the system in real time to search for regions of possible surface motion since the reference images were taken. The software could then flag regions that show movement for retargeting at high resolution as high-payoff scientific targets,

Motion mapping and Mars

Since we have first visited Mars, images returned have always revealed a sandy, desert like environment. In these images it is possible to see sand dunes which are very similar to those in deserts on Earth. On Earth, dunes move with the wind and this movement can be detected from orbit using the motion mapping software that we have developed. It is still an open question as to whether the dunes on Mars are active or have been still since Mars lost most of its atmosphere. We have been applying the motion mapping software to images from Mariner 9, Viking 1 and 2, and Mars Global Surveyor in order to try to detect active dunes on Mars.



Motion mapping software system

The ground based, MPP implementation of our system draws from previous work on QuakeFinder. It is executed from a graphical user interface (GUI) in Matlab which processes the data before it is fed to a suite of parallel motion mapping software and then displays the results graphically. The parallel software is scalable and can be run on a single machine or an entire farm of workstations when the analysis task is large. This system allows for easy experimental setup and fast results so that one can explore the data effectively without waiting for long runs or interpreting difficult to read output files.

First experiments

We began our investigation using images of the Proctor Dune Field in the Hellisponte Montes region on Mars. The Mariner imagery was scanned from photographs (194b5.img, 229b5.img, and 229b6.img). The Viking imagery was downloaded in JPG format from the JPL Planetary Image Atlas <http://www-pdsimage.jpl.nasa.gov/cgi-bin/msearch.pl> at 50 south, 330 west.

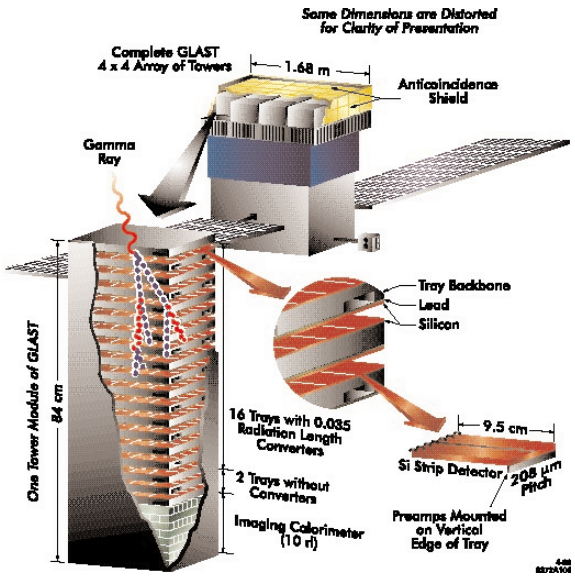


Figure 1.

The first image pair analyzed was m47s330w-01.pgm (from 229b5.img) and v47s330w-01.pgm (from viking-hellisponte.jpg). In order to obtain this pairing, the Mariner image was lightened, and the Viking image was substantially enlarged (see Figure 1 to compare the original images). These images were then compared using QuakeFinder in the following experiments:

Experiment #1	QuakeFinder tile controls
	tile-size 50 50
	tile-skip 10 10
	max-disp 20

Experiment #2	QuakeFinder tile controls
	tile-size 100 100
	tile-skip 10 10
	max-disp 5

The vector field in Figure 2 show the results of these experiments.

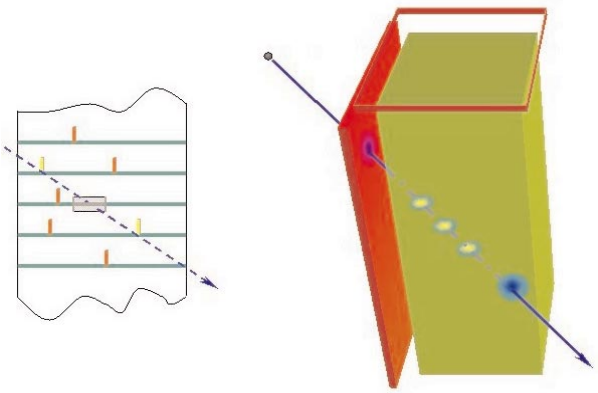


Figure 2. The vector field shows the results of these experiments

As you can see in Figure 2, there is no overall pattern apparent in the vector fields. While there are some small regions of similarly pointed vectors, these regions are easily explained by examining the correlation surfaces associated with each tile. The set of similarly pointing vectors usually represent the jump form one dune top to the next or a jump to a place along the the top of the correct dune but in the wrong location. This can be seen in Figure 3, an example of jumping to the next dune top, and in Figure 4, an example of moving along the correct dune top. While these results could indicate that there has been no dune motion, recent images from MGS strongly indicate that there are active dunes on Mars.

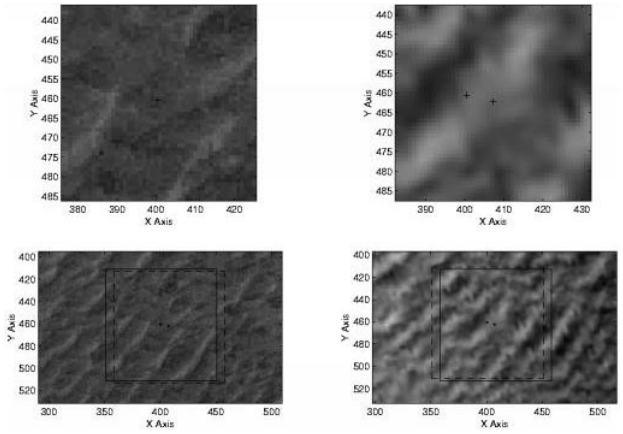


Figure 3. Tiles mismatched across dune tops

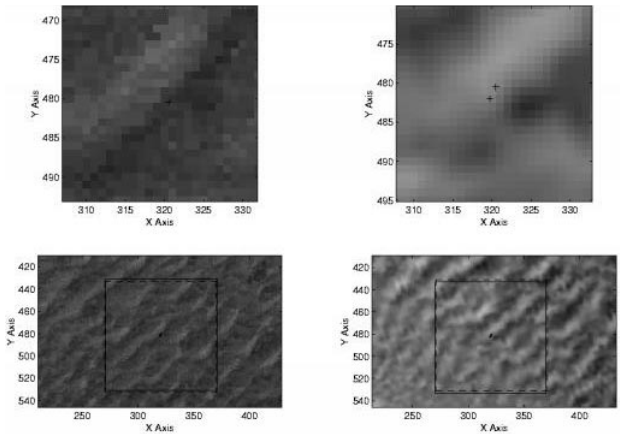


Figure 4. Tiles mismatched along dune tops

A second set of experiments

A limiting factor in the above experiments was the fact that the Mariner image used did not cover the entire dune field. Consultation with the USGS in Flagstaff turned up a mosaic image of the Mariner data which covers the dune field completely and is oriented with north up (proctor.pgm, See Figure 5). The Viking images are also oriented with north up and having the same orientation greatly reduces the registration and preprocessing error. Having larger images of the dune field also gives QuakeFinder more context to lock on to. Using the new Proctor Dune Field mosaic, we ran two more experiments using the following parameters:

Experiment #3	QuakeFinder tile controls
	tile-size 100 100
	tile-skip 10 10
	max-disp 20
	precision 0

Experiment #4	QuakeFinder tile controls
	tile-size 100 100
	tile-skip 10 10
	max-disp 50
	precision 0

These experiments increased the 'max-disp' parameter to allow the matches to be found across greater distances. This generated larger correlation surfaces to examine and possibly detect larger displacements.

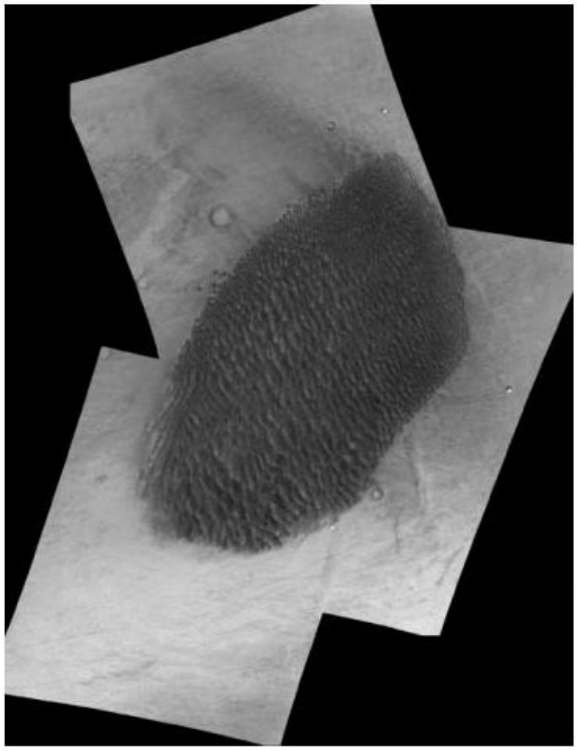


Figure 5. Mariner 9 procter dune field mosaic

Conclusions

The mosaic images improved the coverage of both the dune field and the surrounding area; however, the results were very similar to those of experiments 1 and 2. This is most likely due to the great difference in resolution between these two images. This difference in resolution causes tile matches between the two images to be of lower correlation than would be expected of images of similar resolution. This low correlation can cause problems in the vector field such as those mentioned above. Given the results so far, we can conclude that there is no movement at or greater than the resolution at which we can detect it.

Future work

The resolution and quality of the Viking and Mariner images available to us limits the scales at which we can detect ground motion. The currently ongoing Mars Global Surveyor mission will provide many more high resolution images of sand dunes on the Martian surface. MGS images taken at large time separations would all us to detect the presence or absence of active sand dunes at the best resolutions currently available. However, it is possible that there are active dunes on Mars which change on longet time scales than are available during the MGS mission; therefore, high resolution MGS should from the basis of an image database to be used for on board motion mapping in furute missions.

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White Paper —

DVD Technology for Archival Storage Applications

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DVD technology promises to be a primary storage and distribution media for scientific data products for the next decade. This white paper provides background information on the technology and guidance for the deployment of DVD technology within NASA projects and data systems.

There are five DVD products that have potential applications for archival storage at the current time. Three of them, DVD-ROM, DVD-Video and DVD-Audio all refer to the same manufactured disc, which is much like a CD-ROM but with higher storage capacity. This paper will focus on DVD-ROM, which has the greatest short term potential benefit to NASA missions and data system. Two other products, DVD-R (recordable) and DVD-RAM (rewritable) are locally writable versions of DVD discs which also have great applicability to NASA archiving.

DVD-ROM discs

A single-sided DVD-ROM is essentially the equivalent of a CD-ROM but with a greater storage capacity. A single-sided, single-layer DVD-ROM can store 4.7 billion bytes vs .682 billion bytes for a CD-ROM. The increased capacity is mainly due to smaller pits (.4 micron instead of 1 micron) with smaller track spacing (0.74 micron instead of 1.2 microns). The error correction code is also smaller than on CD-ROM, but is more effective, providing burst error correction twice as effective as that of CD-ROM. The single-sided, single-layer disc consists of a .6 mm "substrate" which is pressed and coated with a reflective layer then glued to a .6 mm blank. The blank can carry labeling information in the form of standard CD-ROM printing or as "pit art", which is pressed into the blank during the mastering process.

The DVD-ROM format also provides for a dual-sided disc which is merely two discs glued together facing away from each other. This results in a double capacity or 9.4 billion bytes per disc. A major problem with this format is that there is no place to print a label on the disc except a small band around the hub. Also, there are no double-sided readers currently on the market so the two sides of the discs have to be considered to be different physical volumes. The main advantage of this format is more data per unit of storage space. To use this format in most existing DVD jukeboxes one would need to load two copies of the disc, with a different side of each disc facing the laser diode. These discs could be used to best effect in DVD-RAM jukeboxes which have the capability to flip discs over and thus could access the entire 9.4 billion bytes.

A third DVD-ROM format is the dual-layer disc, which stores a second layer of data below the first layer. The DVD reader changes its focus depth to read either the first or second layer. Dual-layer discs are produced in one of two ways. In one method, two single-sided .6 mm discs (substrates) are pressed, with one being coated with a semi-reflective layer and the other (which is stamped upside down) with a fully reflective layer. The fully reflective side is flipped over and the two sides are then glued together with transparent glue with the reflective areas at the center of the new disc.In the other method a substrate is pressed with one layer to which a semi-reflective metallic layer is applied. A photo-polymer is added over the reflective layer then is pressed with the second layer. This is coated with a fully reflective metallic layer then a blank substrate is glued on. Both layers use slightly longer pits that are spaced farther apart, thus the storage capacity is slightly less than twice than the capacity of a single-layer disc.

Dual-layer disc production is a new technique and even though the vendors claim that it is reliable, we have heard rumors about possible incompatibility with some readers. Creating a dual-layer disc also introduces a complexity in the pre-mastering process. Two masters have to be sent to the mastering facility, one for each layer. This is normally accomplished by sending two DLT tapes to the vendor. There is also the issue of handling the layer change. There are two options, "opposite track path" where the disc is read from inside to outside on one layer then outside to inside on the other layer, and "parallel track path", where the disc is read from inside to outside on each layer. This choice can have an impact on DVD-Video but should have no impact on data DVD-ROMs. Finally, current DVD drivers for UNIX operating systems (except Linux) utilize the ISO-9660 directory information and not the UDF directory and therefore cannot access the second layer of the dual layer disc.

The fourth DVD-ROM format is double-sided, dual-layer discs with a capacity of 17 billion bytes. Several vendors expect to be able to master these discs in late 1999.

Table 1. CD and DVD-ROM capacity and price comparison

Disc Type	Capacity	Cost (100 discs)*	Cost (per billion bytes)
CD-ROM	.7 billion bytes	$400	$571
Single-sided Single-layer	4.7 billion bytes	$1,500	$319
Double-sided Single-layer	9.4 billion bytes	$3,000	$319
Single-sided Dual-layer	8.5 billion bytes	$4,000	$470
Double-sided Dual-layer	17.0 billion bytes	$?????	$???

* costs are approximate industry average costs as of 6/99.

DVD-ROM usage recommendations

1. The simplest format of DVD-ROM to produce is single-sided DVD-ROM. Pre-mastering and labeling are nearly identical to CD-ROM production. The pre-master can be submitted to some vendors on DVD-R just as CD-R's are used to pre-master CD-ROM's.
2. To produce an archive product with most data per unit volume use dual-sided DVD-ROM (9.4 billion bytes). This will produce an essentially un-labeled volume so should only be used for applications with knowledgable users.
3. To produce a volume which requires between 4.7 and 8.5 billion bytes use dual-layer DVD-ROM. This will require pre-mastering each layer to DLT tape.
4. Don't use dual-layer DVD-ROM if the user community is primarily UNIX-based.

DVD-R

A second type of DVD technology is DVD-R or DVD-Recordable. The DVD-R uses organic dye technology and is essentially equivalent to CD-R media, but with 7 times the storage capacity. The two DVD-R recorders which have been sold to date were both developed by Pioneer New Media Inc. The initial DVR-S101 was limited to a disc capacity of 3.95 billion bytes. It has now been replaced by the DVR-S201 with a capacity of 4.7 billion bytes. This full capacity disc allows DVD-R discs to be used as "one-off" test discs and as pre-master media for DVD-ROM production (for single-layer discs). It is anticipated that dual-sided DVD-R media will be available in the future, but it is not clear that there is any advantage to dual-sided media except for use in a jukebox with a disc flipping capability.

Table 2. Recordable Media Capacity and Price Comparisons

Disc Type	Price	Capacity	Cost per disc*	Cost per billion bytes
CD-R	$200	.68 billion bytes	$ 2.00	$2.94
DVD-R 1st generation	$17,000	3.95 billion byte	$32.00	$8.10
DVD-R 2nd generation	$5,300	4.70 billion bytes	$35.00	$7.95

* costs are approximate industry average costs as of 6/99.

These recorders are equipped with a SCSI-2 (Fast SCSI) interface and two amphenol 50 pin connectors. The Prassi DVD-Rep pre-mastering software for Windows NT 4.0 or Windows 95/98 comes bundled with the recorder. The software is described in the pre-mastering section of this paper. A utility called Crosswriter is also included which provides a limited capability to copy hard disk contents or pre-mastered images to DVD-R. This utility also provides a capability to upgrade the firmware in the DVD-R drive. It is possible to use the recorder on a UNIX system and to produce discs using the "cdrecord" public domain software (NOTE: this software currently writes only ISO-9660 volumes, not UDF-Bridge volumes, and should not be used for archival products).

The production of DVD-R volumes is almost identical to producing CD-R volumes, but with substantially greater data storage and transfer rate requirements. It is recommended that a minimal DVD-R recording system have a 450 mhz processor, 128 megs of RAM, 20 gigabytes hard disc with ultra-wide SCSI interface card for connection to the hard disc and DVD recorder and a 100-megabit per second ethernet connection. Pre-mastering and disc recording can be done in two steps or can be done simultaneously for some projects. If a large number of files are being processed (thousands or tens of thousands), and the original files have long file names (greater than 11 characters for the filename and extension) it is recommended that the data be pre-mastered to an image file. The image file can subsequently be recorded to the DVD-R media. If only a small number of files are involved and the file names are all ISO-9660 compliant then the recording can be done directly from hard disk to DVD-R.

DVD-R usage recommendations

DVD-R is an excellent archival storage product that will become more cost effective as recorder and media prices come down. This technology is best used where data volumes are being distributed to a small user community or are being put in an on-line DVD jukebox. It is anticipated that both recorder and media cost will decrease substantially in the next year (CY 2000), so projects should hold off purchasing recorders and media as long as possible in anticipation of lower prices. The DDL can provide DVD-R recording for modest numbers of volumes NASA projects that are interested in exploiting DVD-R.

DVD-RAM

DVD-RAM uses phase-change technology much like magneto-optical discs. Current discs have a capacity of 2.58 billion bytes per side. DVD-RAM drives are available on the market (e.g. Panasonic LFD-101) for about $600. The standard media comes in double-sided cartridges with a capacity of about 5.2 billion bytes for $39.50 each. These cartridges cannot be opened, therefore can only be used in a DVD-RAM reader. The single-sided cartridges allow the media to be removed and placed in a fourth generation DVD-ROM reader, however this also requires that special UDF drivers be available to read the DVD-RAM format. The UDF driver

issue will probably not stabilize until the spring of 2000. Thus we do not consider DVD-RAM volumes to be portable (in the sense of ISO-9660 or UDF/Bridge volumes) at this time and they are discouraged for archival use. However, many jukebox vendors are migrating from magneto-optic drives to the DVD-RAM drives so it appears the technology will have some success in that arena. DVD-RAM jukeboxes should be able to read all forms of DVD-ROM and DVD-R, including flipping double-sided discs, and we have heard reports that DVD-RAM readers may read DVD-R discs better than some DVD-ROM readers.

DVD-RAM usage recommendations

DVD-RAM may be useful for local on-line and near-line storage. Individual DVD-RAM drives are too small for use in supporting DVD-ROM testing or production and do not seem like a wise purchase until the 4.7 billion bytes per side capacity is reached. DVD-RAM jukeboxes should have the capability to flip the media so that double-sided media can be used. It will be some time before DVD-RAM discs are portable between platforms or between DVD-ROM readers on different operating systems.

Table 3. Rewritable Media Capacity and Price Comparison

Disc Type	Drive Price	Capacity	Cost per disc	Cost per gigabyte
JAZ	$350	2.0 billion bytes	$100.00	$50.00
M/O	$2100	5.2 billion bytes	$100.00	$19.00
DVD-RAM (1-sided)	$600	2.6 billion bytes	$29.00	$11.00
DVD-RAM (2-sided)	$600	5.2 billion bytes	$39.00	$7.50

* costs are approximate industry average costs as of 6/99.

DVD file system

ISO-9660 (International Standard Organization) defines a volume and file structure standard for Compact Disc that allows volumes to be read on virtually any computer operating system. However, ISO-9660 is also very limited, and does not effectively support rewritable or erasible media. In order to develop a standard volume and file structure which could be supported across operating systems, ECMA (European Computer Manufacturerís Association) and ISO have supported the development of ECMA 167/ISO 13346. The Optical Standards and Technology Association (OSTA) has further developed the Universal Disk Format (UDF"!) specification which defines a subset of the standard ECMA 167 to maximize data interchange on optical media. There are several versions of UDF that are supported on different operating systems. UDF 1.02 is the original UDF specification and handles all the requirements for DVD-ROM and DVD-R utilization. UDF 1.5 was developed for adding incremental recording capability based on UDF 1.02 to support DVD-RAM, Magneto-optical devices and other rewritable or erasible media. UDF 2.0 is the latest version of UDF specification. UDF 2.0 is supported on Macintosh system 8.5, Sun Solaris 2.6 and Windows 2000.

The key characteristic for archive applications is the freedom from the ISO-9660's limitations on file name length (12 characters for ISO Level 1, 31 for ISO Level 2) and the limitation to 8 directory levels. UDF supports essentially unlimited length file names and unlimited directory levels. Realistically however, the interpretation of these file names will probably be limited to 256 characters. This should allow an unprecedented level of compatibility for the use of meaningful file names across operating systems.

DVD media

It is expected that DVD-ROM media will have an expected longevity similar to CD-ROM, which is greater than 25 years, and should exceed the length of time that DVD-ROM readers are readily available to play back the media. We have not encountered any read errors in the small amount of DVD-ROM media that we have tested, however much additional testing must be done before we have confidence in the manufacturing process.

The Data Distribution Laboratory has also received and recorded DVD-R media samples from several vendors. These samples were tested by Mark Worthington of CD Associates, Inc using the DVD100MG tester. According to this evaluation, DVD-R media measurements do not differ significantly from DVD-ROM measurements and DVD-R media is expected to perform equally well in DVD-ROM drives. Our tests on a set of a dozen discs recorded in the DDL shows some sorts of error conditions on two thirds of the discs (note that all data on each test disc can be read successfully despite the sometimes high levels of error correction). The types of errors encountered vary considerably. We are working with media vendors and CD Associates to determine the source of recording problems. Another troublesome note is that several pieces of media have radial scratches primarily on the outside edge of the media. We have not been able to determine the cause of these scratches. Since this media industry is in its infancy we would expect disc quality to improve considerably as it matures. However users are recommended to carefully inspect blank discs for manufacturing defects and before and after inserting discs in jukebox systems. In general we have experienced about a one percent error rate in the production of nearly 250 DVD-R volumes.

We have also requested that the National Media Lab perform aging tests on the set of sample DVD-R media that we tested. Unfortunately there is no accepted methodology for aging tests on DVD-R media at this time, so there is no way to conduct valid tests at this time.

Media recommendations

Inspect each piece of media for manufacturing defects prior to use.

DVD-Readers

There are several categories of DVD readers. There are readers with remote control for connection to TV. These units

will play DVD-Video and CD-audio discs but will not read DVD-ROM computer discs and cannot be connected to a computer. There are also readers with proprietary interfaces for connection to specific computer types which can play DVD-Video, CD-audio and DVD-ROM computer discs. Some of these include a video board with an MPEG2 decoder chip and some just provide software MPEG2 decoding. These are usually sold as kits with vendor names like Toshiba, Sony and Hi-Val.

Finally there are readers with SCSI interface for connection to nearly any computer type. These will normally support only software MPEG2 decoding if it is available on the host computer. These are the likely choice for workstation users who need to install DVD hardware on their system. We have distributed a dozen Pioneer DVR-302 DVD Readers to various sites of the Planetary Data System. In order to use the readers on these systems the operating systems of the host computers had to be upgraded to Solaris 2.6, Macintosh System 8.1 and Windows 95, NT 4.0 or 98. Macintosh users had to also install an extension supplied by Pioneer New Media Technologies, INC.

Table 4. Summary of DVD ROM reader generations

DVD Generations	Attributes	Time
1st Generation 1X	not able to read CD-R media	1997
2nd Generation 2X	compatible with CD-R media	1998
3rd Generation 5X	some support for DVD-RAM	1999
4th Generation 10X	supports DVD-RAM	2000

DVD-Reader usage recommendations

Purchasing the latest available generation will provide higher data rates and compatibility with different media types and with higher density media.

If video playback is required, make sure that the DVD software supports file access to MPEG II files and not just to fully formed DVD-Video titles. The RealMedia software packaged with many DVD-ROM kits provides the most features and supports playback of more titles than any other we have tried.

DVD-Changers

There are no DVD changers available on the market at this time.

DVD-Jukeboxes

There are several variations of DVD jukebox systems.The simplest case is the traditional CD-ROM read-only jukeboxes which have been upgraded with DVD readers. These include the NSM series, the Pioneer DRM-1xxx and 5xxxx jukeboxes and the JVC jukeboxes. These jukeboxes can only read single-sided media, resulting in a maximum storage capacity of 4.7 billion bytes for DVD-R media and 8.5 billion bytes for dual-layer DVD-ROM per volume. A second variation is the same type of jukebox but with a DVD-Recorder built in. These devices are useful for automated recording of large numbers of DVD-Rs, but may be somewhat limited in response time during recording operations.

The DDL has evaluated two DVD jukebox systems to date, the DRM-1004XV400 100 disc jukebox from Pioneer and the DRM-5004X CD jukebox which was upgraded with 4 DVD readers. Both jukeboxes are connected to Sparc workstations running Solaris 2.6. In the case of the DRM-1004X it is the sole device connected to one of the SCSI cards on the machine and requires 4 SCSI ID's for the 4 jukebox drives and 1 ID for the jukebox controller. Hardware installation was very straightforward: just plug it in and reboot. The DRM-5004X also requires 5 SCSI ID's. It was somewhat more difficult to install after the upgrade, requiring several days of discussions with Pioneer technical support due to hardware errors related to the placement of the 4 disc cartridges that hold all the discs.

The DDL has also evaluated several software systems for Jukeboxes. Tracer Technologies software is used with the Pioneer DRM-5004X. The IXOS software (Smart Storage) is used with the DRM-1004X and has also been used with several CD-ROM jukeboxes in the DDL.

The Tracer software is far more robust in terms of options for handling the utilization of disc readers in the device. However it is also far more complicated to install and control. It is used with the DRM-5004X primarily to allow the removal of discs from one of the readers after a certain period of inactivity. This is done because the DRM-5004X has a very slow dismount/mount cycle time. By trying to always keep one reader empty we can minimize the delay in loading a disc when a user requests it. We have noticed that the jukebox software seems to corrupt the last few characters at the end of text files that are retrieved from jukebox. We are still investigating this phenomena.

Setting up the iXOS Jukeman 2.3 software involved several steps. First, we needed to choose which sample device description file to use for our jukebox, then customize it based on the jukebox's SCSI ID's. We then edited the Jukeman server configuration file to specify file system filters for our jukebox mount points. The Jukeman's interface to the system is an NFS server which exports different views (based on different types of file system filters) that you can mount locally or remotely. Our setup uses local mounts. This involved specifying which directories to export, and where on the local file system to mount them. After working out the initial configuration, the Jukeman software has been fairly stable on our Solaris machine. The UNIX command-line interface is not very user-friendly, so we developed a web interface which allows users to insert and remove DVDs, start and stop the Jukeman server, and view the current listing of DVDs in the jukebox.

Table 5 summarizes various jukebox systems All provide SCSI-II interfaces to readers/recorders and for jukebox control. All provide read rates of at least 2.7 MB per second. The DVD-RAM and DVD-R systems record at a rate of 1.2 MB per second. The maximum data capacity is based on 4.7 billion bytes for single-sided DVD-ROM or DVD-R, 9.4 billion bytes for double-sided DVD-ROM or DVD-R. Capacities will be about half of the stated capacities for DVD-RAM

discs. DVD-ROM or DVD-R volumes will have to be placed in caddies to be used in DVD-RAM jukeboxes.

Jukebox utilization recommendations

Avoid jukeboxes that do not provide the capability to flip discs. This capability will be critically important to the full utilization of dual-sided DVD-R and DVD-RAM, and of DVD-ROM double-sided, dual-layer volumes in the future.

Avoid jukeboxes with RS-232 interfaces to the robotics. This just complicates the installation and utilization of these devices.

Be sure that recorder hardware (DVD-RAM) in the jukeboxes is field upgrade-able as new higher density recorders become available.

Table 5. Summary of DVD-ROM/DVD-RAM Jukebox System characteristics

Vendor Name	Model	# of Drives	# of slots	Max. Data Capacity	Magazines	Media Exchange Time(sec)	Caddy Req'd	Single or Dble-sided
Cygnet Storage Solutions	InfiniDVD	4	500	2.3TB	11	N/A	NO	SS
Cygnet Storage Solutions	DVD	8	250	1.10 TB	11	N/A	NO	SS
Cygnet Storage Solutions	DVD-100	1	100	470 GB	5 (20 discs)	10	NO	SS
NSM Jukebox	Mercury	4	150	705 GB	3 (50 discs)	4	YES	SS
NSM Jukebox	Satelite	5	135	635 GB	N/A	2.5	YES	SS
NSM Jukebox	Galaxy	14	620	2.9 TB	N/A	6	YES	SS
NSM Jukebox	Jupiter	6	385	1.8 TB	N/A	4	YES	SS
Pioneer	DRM-1004X	4	100	470 GB	N/A	3	NO	SS
Pioneer	DRM-5004X	4	500	2.3 TB	5 (100 discs)	18	NO	SS
Pioneer	DRM-7000	2/16	720/370	6.8 TB	14 (50 discs)	9	NO	DS
ASM Jukebox	DVD-1000	1/6	168/152	789 MB	4	N/A	YES	DS
ASM Jukebox	DVD-1100	1/12	287/263	1.34 TB	4	N/A	YES	DS
ASM Jukebox	DVD-1200	1/24	67/639	3.22 TB	4	N/A	YES	DS
ASM Jukebox	DVD-1300	1/32	1087/1031	5.10 TB	4	N/A	YES	DS
ASM Jukebox	DVD-1400	1/44	1587/1507	7.45 TB	4	N/A	YES	DS
JVC	MC-2120	up to 6	100	470 GB	2 (50 discs)	2	NO	SS
JVC	MC-2200	up to 6	200	940 GB	4(50 discs)	4	NO	SS
JVC	MC-2620	up to 6	600	12.82 TB	2 (50 discs)	6	NO	SS
ASCA	AM250DVD	1/6	200/250	2.3 TB	5 (50 discs)	5	YES	DS
ASCA	AM750DVD	1/12	600/750	5.8 TB	15 (50 discs)	5	YES	DS
ASCA	AM1450DVD	1/24	1100/1450	7.5 TB	29 (50 discs)	5	YES	DS
Plasmon	D-120	2/4	120	564 MB	N/A	7	YES	SS
Plasmon	D-240	2/6	240	1.1 TB		7	YES	SS
Plasmon	D-480	2/6	480	2.4 TB	N/A	7	YES	SS

DVD artwork and labeling

Key considerations in DVD artwork vs CD artwork are the availability of pit art for DVD-5 discs and the lack of labeling for DVD-10 discs. Pit art is produced by pressing a design into the blank substrate which will be glued to the data substrate.

If one wants to follow the labeling tradition developed for CD-ROM titles then either DVD-5 or DVD-9 single-sided volumes will need to be produced. These formats allow exactly the same kind of labeling that is used on CD-ROMs. The DVD-10 format provides only a small ring for labeling, therefore can carry only some kind of identification number and not the kind of descriptive images or text that is found on CD-ROMs. The type of printing that can be used on DVD-10 and DVD-18 is also limited, so it may not be possible to match the labeling used on existing products if either of these formats is used.

DVD mastering and replication

Most CD-ROM mastering and replication plants have been working for several years to accommodate DVD-ROM manufacturing. The initial DVD discs were single-sided, single-layer. The next development step was the production of double-sided, single-layer discs. The third development is the production of dual-layer discs. The final step will be the production of double-sided, dual-layer DVD-ROMs sometime in later 1999 or 2000.

Until recently the only input media for pre-mastered DVD content was DLT (Digital Linear Tape). A separate DLT pre-master tape is required for each side of a double-sided volume and also for each layer of a for a dual-layer disc. Several vendors also accept DVD-R volumes for input for producing single-layer discs, but this is probably copied to DLT before the master disc is cut. All dual-layer discs will still require DLT pre-master tapes because of the need for information about the sizes and transition point between layers.

Pre-mastering Software

DVD pre-mastering is similar to CD pre-mastering except a lot more resources are required on the host machine. A high speed Ultra SCSI interface to both the hard disk drive and to the DVD recorder are mandatory for real-time recording. It is convenient to have 20 or 30 gigabytes of disk space available on the pre-mastering system as a collection area for input data files and a storage space for image files when pre-mastering and recording cannot be done in real time.

The DDL has used the Prassi software to pre-master several hundred DVD-R discs. Pre-mastering is a fairly simple drag and drop procedure to select files for inclusion on the disc. This drag and drop procedure prepends the folder name of the source data all the way to the root of the drive, even if the data is selected from within a folder. This necessitates an editing step where the unnecessary folder names are removed from the path name for the selected files and folders.

In order to produce a UDF/ISO-9660 compliant Bridge disc the pre-mastering step must build an 8.3 compatible file name for every file on the volume. In the event that there are a lot of very long file names this can become an extremely time consuming process. In some of our early pre-mastering efforts this process could take as much as 12 hours to complete. For this reason it is important to have a high-performance workstation for pre-mastering operations.

The total capacity of a DVD-R disc is 4,706,074,624 (4.7 media) and 3,958,407,168 (3.95 media). These numbers are reduced to about 4,525,229,056 of user data before pre-mastering, and 4,526,604,288 for the pre-mastered image.

A rough formula for computing disc overhead = (380 + number of directories + number of files) * 2048. This value needs to be subtracted from the storage capacity of the media before be added to the data.

Table 6 summarizes vendors and prices of DVD pre-mastering software. As can be seen, there are no UNIX-hosted pre-mastering packages currently on the market, though a couple are expected in the next few months. All of these pre-mastering systems provide the capability for the user to select a set of directories and files for inclusion in the disc and to produce either a DVD image file or to record directly to DVD-R. Many of the packages DO NOT support writing dual-layer DLT tapes.

Table 6. Summary of DVD pre-mastering software

Vendor	Product Name	Operating System	Dual-Layer Premium	Price**
Adaptec	Toast DVD	Mac	No?	$198.00
Elektroson	Gear Pro DVD	Win 95/98, NT	Yes?	$2,995.00
Prassi Inc Software USA.	DVD-Rep	Win 95/98,NT	No	$1,050.00
SmartStorage	DVD Maker	Win 95/98,NT	Yes	$2,500.00
Tracer Technologies	?	Unix	coming soon	
Young Minds Inc.	DVD Studio	Unix	?	$6,995.00

** Prices from vendor web pages as of 10/1/99

Pre-mastering software product descriptions

The following material is extracted from product descriptions provided on vendor websites and has not been checked for accuracy.

Adaptec's Toast DVD <http://www.adaptec.com>

"Adaptec's Toast DVD software is a special version of Toast 3.5 Compact Disc-Recording software for DVD title developers. Toast DVD allows users to create their own DVD-ROM, DVD-Video and DVD-R CDs. Using a Macintosh Personal Computer with Adaptecís Toast DVD, you can create master DVD-ROM or DVD-Video disc images, suitable for mass replication, or for creating one-off DVD-R discs. Support for UDF 1.02 Bridge format (required for DVD-ROM and DVD-Video). Support for the Pioneer DVR-S101 DVD-Recordable drive. Ability to create DVD disc image on hard disk or other removable media. Backward-compatible with Toast 3.5 and higher, and supports all formats supported by Toast 3.5. Supports removable SCSI devices (hard disk, SyQuest, Jaz, etc.)"

Elektroson <http://www.gearcdr.com>

"GEAR Pro DVD v2.0 is especially designed for fast data transfer rates while ensuring data integrity. Create hybrid ISO 9660/UDF discs with GEAR DVD. Utilizing the best in CD-Rewritable technology, GEAR DVD allows users the advantage of this new medium and ease of repeated use. Besides creating the large 3.95 GB and 4.7 GB Digital Versatile Discs (DVD) in Universal Disc Format (UDF), GEAR DVD offers the best of both worlds by letting you create hybrid ISO 9660/UDF discs, being backwards compatible with the ISO 9660 file format."

"Formatting of DVD-ROM titles up to 4.7 GB for DVD-R recording. Support for the Pioneer DVR-S101 and DVR-S201 recorders, to write DVD-R media up to 4.7 GB Supports all CD-R and CD-RW recorders (SCSI and IDE). Supports new ISO/UDF Hybrid formatting developed by GEAR Software. New option for writing beyond the disc capacity. Supports all features of GEAR Pro v 4.4 (advanced formatting options, cyclic buffering, foreign images, batch and log files). Supports CD Jukeboxes (Pioneer, Grundig, ASM, etc.). Support for premaster tape units (Exabyte, DAT, DLT) to write a premaster tape for CD or DVD media, optionally in DDP (Disc Description Protocol) format. DDP 1.01 is supported for mastering CD media and DDP 2.10 for mastering DVD media."

Prassi Software USA, Inc. <http://www.prassi.com>

"The first complete pre-mastering for DVD-R, with copy and record on-the-fly. DVD Rep"! is a Win 32 (Windows 95Æ, Windows 98Æ, and Windows NTÆ) professional software application for DVD-R mastering. DVD Rep is UDF compliant and masters on-the-fly, via disk image UDF/ISO Bridge or pure UDF file system formats. Writes to DVD-R, DVD-RAM, and tape."

"DVD Disc Copy- Directly from SCSI or ATAPI DVD-ROM drives the user may master copies perfectly mirrored, bit-for-bit, from the original source. disc. Video_TS Support - Master DVD Video from previously prepared file structures. On-the-fly Recording - Prassi's lead in on-the-fly recording capability not only increases throughput but also liberates the user's hard drive. Any resultant DVD disc can be examined in detail with respect to its contents courtesy of Prassi's design approach. CD-RW Support - Because CD-RW media is readable in Standard DVD-ROM drives, the user of DVD Rep may record UDF compliant file systems onto CD-RW media and read them in DVD-ROM drives. This capability will be of particular importance to those authoring DVD-ROM titles with respect to testing in the development cycle. File System Level Verify - Critical to professional replication is the aability of DVD Rep to first verify file format creation for accuracy and completness prior to committing the final work to mass replication. System Integration - DVD Rep is seamlessly integrated in the Window environment. Pre-mastering a UDF dis does not require any external utility. DVD Rep has a simple, effective, professionally integrated Windows shell interface and is for use with DVD-R drives in professional mastering application environments."

Smart Storage <http://www.smartstorage.com>

"SmartStor DVD Maker provides a sophisticated data preparation tool for users who wish to create and validate premastered titles. Using DVD Maker, these images are tested and verified before being sent to the mastering plants for mass replication. Users output the title to either industry standard DLT tape format or a DVD-R check disc to produce DVD-Video and DVD-Hybrid ROMs."

"DVD Maker's emulation tool eliminates mistakes and saves money, quickly allowing users to mimic the DVD-ROM that will be produced. This drive letter emulation allows users to run executables both on Windows NT and on other target platforms, via networking, to ensure that the title behaves exactly as designed. Further, the emulation system provides different file system views so designers can see how

the title will appear on different operating systems on a computer. Finally, a premastered image is made, allowing the user to verify the final copy before it is sent for mass replication via DLT tape."

"Supports DVD-ROM, DVD-Video, and DVD-Hybrid formats. Easy-to-use drag and drop interface. Accepts industry-standard Video Object (VOB) files. Comprehensive file system support (ISO, Joliet, and UDF). Rapid virtual and file emulation for testing DVD titles. Networked access for emulation on non-Windows NT platforms. Disc copy and compare utilities. Output to industry standard DDP2.0 DLT single and double layer DLT tape format, Output to DVD-R recorders for creation of check discs."

References/Resources

DVD Demystified, Jim Taylor. Describes DVD technology focusing on DVD-Video. This web site provides an extensive set of information about DVD technology, though it's focus is on DVD-Video. Emedia Professional - Monthly articles about DVD software and hardware. ■

Mapping the Course for Solar System Exploration

Each year, the American Astronautical Society's (AAS) national conference provides a forum for eminent engineers, scientists, and policy makers from industry, government, and academia to discuss significant issues about space exploration and development. To this end 1999's program, held on November 16-18 in Pasadena, California, featured sessions on Current Visions; Robotic Exploration and Outposts; Destinations; and Technology Challenges - in keeping with the conference theme, "Mapping a Course for Solar System Exploration."

Following the welcome by the AAS Vice President, Harvey Willenberg, the Director of the Jet Propulsion Laboratory (JPL), Ed Stone, acting as the Meeting's Honorary Chair, opened the conference, along with the Vice President and General Manager of Boeing Reusable Space Systems, Rick Stevens. Stone presented his lecture, "The Role of Robotic Outposts in Establishing a Permanent Presence in Space," as the recipient of 1999's Carl Sagan Award. Stone's lecture (accompanied by a series of slides) was the third in the series of Carl Sagan Memorial lectures. Rick Stevens presented the keynote address, "Enabling Exploration Beyond Leo."

New discoveries related to the Moon and Mars have recently been made by an exciting program of space exploration. Large hydrogen deposits have been discovered on the Moon by the Lunar Prospector and Clementine. The database of the Martian surface and atmosphere is steadily improving through an ongoing series of missions being launched at every flight opportunity. Indications of biological activity from Martian meteorites have generated additional interest in Mars. Planned exploration missions include visits to near-Earth asteroids, comets, Mars, and Europa. - Introduction excerpt.

The conference offered technical, programmatic, and philosophical sessions on program plans, visions, and recent results of solar system exploration. Additionally, an overview of ongoing and future activities was presented, as well as discussions about why we explore and what technologies and experience are needed to enable such endeavors. The presentations featured nationally known leaders from industry, NASA, and universities. The program included technical sessions, a student poster session, and an exhibition arena, which provided demonstrations and models of existing and potential technology to enable the achievement of meeting exploration goals and challenges.

Technical session one, entitled "Current Visions", discussed why we explore and where we plan to go, including current reference missions and the complementary roles of humans and robots. Session two, "Destinations," described planned programs to Mars,the buildup of a Mars-based infrastructure, and the robotic exploration of other bodies. Session three, "Robotic Exploration and Outposts," covered the role of space exploration in answering the grand questions in science and a discussion of solar system destinations, including asteroids, LaGrange points, Europa, and the outer solar system in addition to the Moon and Mars. Session four,"Technology Challenges," addressed the technologies required for a vibrant space exploration program and current progress and plans toward developing these technologies.

NASA presentations for Current Visions were:

- Origins Program - The Search for Our Cosmic Roots and Galactic Cousins. For abstract email Firouz Naderi at < Firouz.M.Naderi@jpl.nasa.gov>
- JPL - New Horizons in Solar System Exploration. For abstract email Doug Stetson at <dstetson@pop.jpl.nasa.gov>
- JPL - Humanizing Robots in Exploring the Solar System. For abstract email Rich Doyle at <rdoyle@mail1.jpl.nasa.gov>

NASA/Caltech presentations for Robotic Exploration and Outposts were:

- JPL - The Mars Surveyor Program. For abstract email J.F. Jordan at < jjordan@pop.jpl.nasa.gov>

- JPL - Mars Network: A Telecommunication and Navigation Infrastructure for the Coming Decade of Mars Exploration. For abstract email C. Edwards at <cedwards@mail1.jpl.nasa.gov>
- JPL - Precision Land Technologies for Mars Exploration. For abstract email Rob Manning at <mmannin@jpl.nasa.gov>
- Glenn Research Center - Mars Surface Power Considerations: Spanning Robotic to Human Outposts. For abstract email R. Cataldo at <robert.L.Cataldo@lerc.nasa.gov>
- JSC - In-Situ Resource Utilization: Strategic Plans and the First Flight Demonstration. For abstract email David Kaplan at < David.I.Kaplan1@jsc.nasa.gov>
- JPL - Athena Rover. For abstract email Barry Goldstein at <bggoldst@mail1.jpl.nasa.gov>

NASA presentations for destinations were:
- JPL - Near-Earth Asteroids. For abstract email Steve Ostro at <ostro@echo.jpl.nasa.gov>
- Caltech - Mars Outposts - a Key to Exploring Mars. For abstract email Bruce Murray at <Bruce.C.Murray@jpl.nasa.gov>

NASA presentations for Technology Challenges were:
- JPL - Technology Develoopment and Infusion in the Faster, Better, Cheaper World. Tony Spear
- JPL - Environmental Challenges For Next Generation Exploration Missions. Dave Rodgers at <drodgers@pop.jpl.nasa.gov>
- NASA HQ - New Concepts for Exploration in the New Century. For abstract email John Mankins at <jmankins@mail.hq.nasa.gov>
- Ames Research Center - NASA and the Challenge of Information Technology. For abstract email Tony Gross at <agross@mail.arc.nasa.gov>
- JSC - Micro/Nanotechnology: An Example of "Spin-On" Technology for Space Systems. For abstract email Bob Smith at <robert.h.smith1@jsc.nasa.gov>

The California Institute of Technology participated in the student poster session, presenting "A New Plan for Sending Humans to Mars: The Caltech Mars Society Mission 2.0." The Caltech Mars Society Mission 2.0 is a complete description of a five person expedition to the Red Planet targeted at the 2011 (cargo), 2014 (crew), and succeeding opportunities.

The mission features:
- increased redundancy of design for reduced development
- an innovative MAV design that reduces trans-Mars injected mass through the use of zero boil-off, parallel staged LOX/hydrogen ascent stages
- the Janus Launch Vehicle, an Energia-derived heavy lifter, capable of up to 150,000 kg to low Earth orbit
- increased redundancy for maximum safety
- no nuclear thermal rocketry and no activation of nuclear powwer sources until Mars surface

Other academic institutions participating in the student poster session were the University of Arizona, Texas A & M University, Georgia Institute of Technology, San Jose State University, and the University of California - San Diego.

The AAS, which was established in 1954 as a professional, non-profit organization, is dedicated to supporting interest in space activities through publications, professional meetings, and educational initiatives.

See Stone's slide lecture at <http://www-sisn.jpl.nasa.gov/issue54/stone.html>. ■

An XML-Based Prototype ADC Search Service

James E. Gass and Brian M. Holmes (Raytheon ITSS)

The Astronomical Data Center's (ADC) on-going efforts to improve data discovery have resulted in a prototype search service based on eXtensible Markup Language (XML) technologies. This experimental service gives ADC's users greater control when searching the ADC'scollection of published data than is available through the established ADCsearch facility. This prototype uses off-the-shelf Java class libraries and object-oriented programming techniques to implement a powerful content-based search capability.

ADC's XML research project, begun in early 1999, has already produced XML documents that describe some 2,400 separate ADC data sets (roughly 85% of the ADC's holdings). This body of dataset descriptions is an excellent testbed for prototyping improved ADC data location services.

How it works

XML uses customized HTML-like tags to markup information. Unlike HTML, the tag names identify the informa-

tion content, rather than the structure or display of the information. The set of tags and their attributes are defined as needed, or specified in a Document Type Definition (DTD) selected to suit the information at hand. The result is self-describing documents. The rich content tagging of these descriptions will make it possible to perform highly focused searches for ADC data sets that meet users needs.

The Document Object Model (DOM) is a standard way for programs to access and manipulate XML documents. It specifies how XML documents can be represented as objects during the execution of a program. The German National Research Center for Information Technology's Integrated Publication and Information Systems Institute (GMD-IPSI) provides a package that saves this run-time representation of an XML document to a binary file as a "Persistent DOM" or PDOM. While the PDOM does not create an inverted index of the words in the document, it does index the location of each element tag. This provides very fast access to all of the tags, for example, even if the XML document is very large.

Demonstrating ADC XML

At this month's American Astronomical Society meeting in Atlanta, Georgia, the ADC featured its work with XML technologies at an exhibit booth and in display papers that reflecting the current emphasis within the ADC to understand how to apply XML to improve services and data acquisition activities. For the demo, the staff created a single large (22MB) XML document by concatenating the 2,400 XML data set descriptions of ADC's holdings, and used the PDOM facility to create a binary file representation of the large XML document's hierarchy.

The resulting 29MB file is our "database" of data set documents, and is accessed with GMD-IPSI's XQL query package.Initially, the user is given the choice of a simple HTML form-based interface or a more comprehensive Java applet interface. The form parameters (form-based interface) or the XQL query (applet-based interface) are included on the URL to the web server.

Applying XML technologies

The web server recognizes that the URL represents a servlet request, and passes it on to the Apache JServ servlet engine. JServ dispatches the request for execution by the QueryServlet. The Java servlet constructs an XQL query from the form parameters or uses the applet's XQL query directly, calling the GMD-IPSI's XQL query engine to find the matching data sets in the PDOM.

The results of the query are in XML format, so they are transformed with an eXtensible Stylesheet Language Transform (XSLT) script into HTML for display in the user's browser. Java classes from IBM's XML4J parser and LotusXSL processor packages are used to perform the transformation.

This application of XML technologies to the ADC's holdings does allow for much more precise searches than are possible with the established search service. For example, you can now easily find ADC tables published since 1998 with information about the Ca II line.

Conclusions

This project has shown that useful XML applications can largely be implemented with free tools and code packages. Even though XML technologies and tools are rapidly changing, they are already useful, and their adherence to various W3C standards makes it easy to combine tools from different sources into a working application.

The prototype XML search application has provided good feedback for our efforts to design a generally useful DTD for astronomical data. Future work will include applying XML markup to data tables to permit record level search and retrieval, refined user interfaces, development of help files and tutorials, and expanding the XML data set descriptions to include all ADC data sets.

Editor's note: Originally published in the ADC online newsletter.

Learn more about the ADC and XML. Compare the established search service <http://adc.gsfc.gov/adc/sciencedata.html#search> and the prototype ADC search service with its two user interfaces at <http://xml.gsfc.nasa.gov/search-demo/intro.html> and <http://xml.gsfc.nasa.gov/search_demo/intro.html>. ■

NISN in the CSOC Era

NASA's telecommunications provider, the NASA Integrated Services Network (NISN), held its Fifth Customer's Forum last fall to interface with its customers and to report on the state of the network following the first year of service in the Consolidated Space Operations Contract (CSOC) "era." The contract, which began in Jan of 1999, accomplished the phase-in of nine legacy contracts at Goddard Space Flight Center, Jet Propulsion Laboratory, Marshall Space Flight Center, Johnson Space Flight Center, and Kennedy Space Flight Center, transitioning to CSOC on schedule with no major issues. The field sites also being supported are Wallops Island, White Sands, Merritt Island, Goldstone at Barstow, Canberra, Madrid, Guam, and other remote tracking stations.

Beth Pascell of the NISN customer interface group welcomed all to the forum, held in Huntsville, Alabama, and introduced NISN's Project Manager, Rick Helmick. Helmick began the sessions with an overview of NISN's staffing and mission. NISN was implemented to serve the needs of all of NASA's users for the transmission of digital data, voice, and video information in the most cost-effective manner possible. The single integrated network project replaced the independent special purpose networks that had served individual customers over several decades.

I survived the first year. Illustration presented by Doug Tighe, CSOC Program Manager.

Meeting the challenge

Key goals to be met are the maintenance of operational performance for NASA and its science customers, reduction of costs of operations and maintenance of NASA's ground systems and communications infrastructure, enabling comprehensive and meaningful small business participation, and the privatization and commercialization of NASA's infrastructure to further reduce costs. Additionally, safety is an overarching area of emphasis.

Providing services

NISN provides a variety of telecommunication and networking services, among them:

- mission critical routed data service
- real-time critical routed data service
- custom services
- conference services

Mission critical routed data services provide a mission critical level of data networking connectivity through the use of the IP suite with very controlled access and security measures. The mission critical IP service is engineered as a very closed system to support spaceflight mission critical telemetry and data flows.

Real-time critical routed data services provide a mission critical level of data networking connectivity with emphasis on meeting real-time telemetry transport through the use of the IP. This service is engineered with a high level of redundancy to achieve the added level of availability. It employs the same security and connectivity features and limitations as the mission critical service.

Custom services are specifically designed and engineered to meet unique NASA programmatic requirements. These services may be used both for spaceflight mission critical applications and for general administrative and support requirements possessing unique attributes. These services arre customized for each client.

Conference services include planning, design, management, and implementation of IT support for NASA conferences and symposia. These services include:

- email
- local area network installation
- pc/workstation installation/support
- voice/video teleconferencing
- routed/dedicated data services
- facsimile
- audio/visual support
- technology demos

NISN currently supports the following conferences:

- American Astronomical Society
- Bio-Astronomy Meeting
- American Meteorological Society
- Division for Planetary Sciences
- Lunar and Planetary Sciences
- Meteoritical Society
- The Oceanographic Society
- High Energy Astrophysics DIvision
- Consolidated EOS subworking groups

NISN also currently provides custom and all regular services to Russia.

Learn more about NISN and the Fifth Customer Forum at <http://www.nisn.nasa.gov>. ■

Through its many outreach programs NASA makes significant contributions to American education systems and to institutions dedicated to improving science literacy, and provides science research results and information to the general public. This newsletter's objectives are to universally educate and provide the community with access to reports of hands-on technology research.

Using Videoconferencing to Increase Minority University Competitive Research

James Harrington and Valerie L. Thomas, Minority University-SPace Interdisciplinary Network, Goddard Space Flight Center

The Minority University-SPace Interdisciplinary Network (MU-SPIN) Project was developed in 1990 to ensure that Historically Black Colleges and Universities (HBCU's) and Other Minority Universities (OMU's) had Internet connectivity, to provide training for faculty and students, and to enable the MU-SPIN community to use the Internet to support interdisciplinary research. MU-SPIN minority constituents include African Americans, Hispanics, and Native Americans. Funding of seven MU-SPIN Network Resources and Training Sites (NRTS) in 1995 greatly enhanced the Internet connectivity and training components of the MU-SPIN Project. The NRTS project provided regional training sites at the following seven HBCU and OMU campus's:

- Elizabeth City State University (ECSU), NC
- South Carolina State University (SCSU), SC
- City College of NY (CCNY), NY
- Tennessee State University (TSU), TN
- University of Texas at El Paso (UTEP), TX
- Prairie View (PVAMU), TX
- Morgan State University (MSU), MD

The NRTS provided Internet connectivity and training for their consortia of Kindergarten Through Grade 12 and college/university partners.

Today, with completion of its connectivity goals, the MU-SPIN Project is focused on applications of Internet access. Workshops now support minority institutions' use of NASA's Earth and space science educational products. For example, the Space Mission Involvement Workshop Initiative is a collaborative opportunity that supports interdisciplinary space science mission research. According to the manager of NASA's Explorer Program, there has never been a minority university principal investigator (PI) in the history of the Explorer Program. MU-SPIN is addressing this issue with the goal of expanding the number of opportunities applied for and won by minority PI's.

Space Mission Involvement Workshop (SMIW) Videoconference

To introduce the MU-SPIN community to the space science mission involvement and Announcement of Opportunity (AO) process and representatives, MU-SPIN hosted its first Space Mission Involvement Workshop videoconference on December 9 -10, 1999. MU-SPIN used the videoconferencing vehicle to give many of its geographically dispersed constituents (African Americans, Hispanics, and Native Americans) an introductory understanding of space mission involvement research. Presenters were from NASA's Space Science Enterprise with some from the Naval Research Laboratory (NRL), Los Alamos National Laboratory (LANL), and South Carolina State University. The agenda included the following topics:

- What is space science?
- Explorer Program opportunities
- how to respond to NASA Research Announcements and AO's
- how to develop a winning proposal
- what to do once the proposal is funded
- space science strategic planning
- insights from experienced PIs and Co-PIs

Morgan State University acted as the main videoconference site. A remote-location presenter demonstrated seamless integration of local and remote presentations. Presenters reflected the composition of MU-SPIN's constituency, including a Navajo Indian who was an Orbiting Solar Observatory (OSO) Program Manager in 1963; an African American astrophysicist who designs, builds, tests, and processes data from space science instruments with minority high school and college assistants; HBCU faculty that man-

age space science research projects and a satellite operations control center; a Hispanic NASA director responsible for systems, technology, and advanced concepts; and a young female African American aerospace engineer with a variety of hands-on experiences in space science projects.

Participant feedback: Success!

The consensus of the participants and the presenters was that the MU-SPIN Space Mission Involvement Workshop videoconference was very successful. A considerable amount of synergy and excitement was generated during the videoconference as presenters provided an excellent baseline level of information on space mission involvement research and people from across the country were able to interact with the presenters. On a scale of 1-5, the videoconference met the participants' expectations (average rating was 4.4) and presentations were helpful in understanding the material (average rating was 4.5). On a scale of 1-3, participants rated the presenters (average rating was 2.5) as Good to Outstanding. Participants unanimously indicated that they would recommend this videoconference to their colleagues and that they would participate in another MU-SPIN SMIW that will focus on Team Building and will include the space science community, industry, and minority universities.

Participant feedback indicated that videoconferencing is a very effective delivery system because it offers decreased travel time, participant interaction, access to broader knowledge, and elimination of travel-related paperwork. Participants found this vehicle to be an efficient way to communicate ideas, opportunities, and encouragement. They identified as the most valuable aspects of the videoconference the interchange of information, especially researcher experiences, project descriptions and operations, information on research and student internship opportunities, and step-by-step discussions on the submission and review of proposals. A participant characterized the videoconference as having "presenters as close as real life can get" and, according to another, "Conferencing without leaving home base is very cost effective and also practical."

Where do we go from here?

Future videoconferences will be designed around two themes that are valuable in preparing winning proposals: 1) obtaining hands-on experience with small space science or as a member of a space science mission team, and 2) early development of proposals. The MU-SPIN Program will assist the minority research community by funding full release of candidate Principal Investigators. This will facilitate MU-SPIN proposal teams. Other SMIW videoconferences will focus on:

- participation in flight training programs such as balloons or Get Away Special (GAS) Cans
- team building with minority universities, majority institutions, government agencies, and industry
- pre-proposal support for Explorer Program AO's
- expanded use of information exchange and PI experiences

Participant feedback offered many suggestions for future conferences, such as including more discussions by people with hands-on experience; more solid research opportunities for computer technology; collaborations for joint (minority and majority institutions) funding; and Astrobiology and other NASA Enterprises (especially, Earth Science), Sub Orbital opportunities, Get Away Special (GAS) Can opportunities, and theoretical and analytical opportunities. Participants suggested that more students would participate in the SMIW by scheduling around student requirements (i.e., exams, registration, and graduation).

Minority universities that have space science research expertise and involvement with space science research projects are excellent candidates for participation in space science mission teams. The MU-SPIN Project Manager's planned follow-up actions will address MU-SPIN's goal for enabling its constituents to use the Internet to support interdisciplinary research, such as for the Explorer Program's University class Explorer (UNEX) Announcement of Opportunity (AO). To be effective, collaborative teams must include multiple minority universities as well as partnerships with members of the space science community and industry. Regardless of which path MU-SPIN takes, a SMIW participant offered the following advice: "Keep doing similar good work."

Learn more about MU-SPIN at <http://muspin.gsfc.nasa.gov/>. ■

Through its many outreach programs NASA makes significant contributions to American education systems and to institutions dedicated to improving science literacy, and provides science research results and information to the general public. This newsletter's objectives are to universally educate and provide the community with access to reports of hands-on technology research.

NASA Data and Technology aid Teachers and Students in Real Life Learning Experiences

Betty Sword, CASDE, Jet Propulsion Laboratory

Students at a Nebraska high school were enthusiastic participants in a wetlands restoration proposal using aerial imagery and tools developed by the Consortium for the Application of Space Data to Education (CASDE) project, which provided them with possibilities for learning and problem-solving that previously would have been very difficult to experience. This project, called the Nathan's Lake Wetland Restoration, involved taking one small wetland back to it's original 1944 size, and is now under consideration for actual implementation by the Army Corps of Engineers.

This is one of many examples of students and teachers making creative use of the data and tools provided by NASA/CASDE to enhance classroom learning and provide practical, real-life uses for Earth Science images and data. CASDE - the Consortium for the Application of Space Data to Education - began in 1995 as a response to the need to make NASA's data more easily accessible to students and educators. CASDE is a partnership of: the University of Nebraska at Lincoln's Center for the Advancement of Land Management Information Technologies, NASA's Jet Propulsion Laboratory, and the University of Nebraska at Omaha's Office of Internet Studies. It represents an evolving consortium of educators, engineers, scientists, and other professionals dedicated to providing the educational community with vast amounts of NASA imagery, tools, and interdisciplinary learning activities, distributed freely over the Internet. CASDE tools, tutorials, and a useful "building-block" curriculum structure introduce the basics of interpreting space imagery, particularly of the Earth, to teachers, students, and others:

- Thousands of teachers and students have been introduced to space imagery and its educational uses via CASDE workshops and course work, and tens of thousands through the CASDE web sites and "WebShop" - an on-line teacher training program.
- Over 200 teachers have participated in developing motivating space imagery activities for students, so that teachers across the country can access and use these impressive resources effectively in the classroom.
- Teachers and students have eagerly adopted CASDE's DataSlate software tool and used it to create new lesson plans using space data.
- Thousands of CASDE CD-ROMS have been distributed to the education community. These make available DataSlate, data sets, and a subset of CASDE's growing data base of "building blocks."
- Virtual Nebraska, developed by CASDE as the first phase of "Virtual America," receives close to 20,000 hits/month. Virtual America is a web-based structure for organizing earth data: an archive of digital space and aerial photography, real time satellite imagery, tutorials, and lessons.
- In addition to the on-line curriculum activities and tutorials, hands-on "Teacher Toolboxes" covering Image Interpretation and Spectroradiometry are available for checkout. The toolboxes contain teacher background information, activities and tools introducing the basics of each topic.

The curricular approach developed by CASDE's educational partners involves the concept of "curriculum building blocks" that contain tools, data, tutorials, curriculum standards, assessments, and a sample lesson or instructional activity. An important feature of the CASDE building blocks

is the direct reference to published curriculum standards in science and mathematics within the building block links and structures. The careful connections to these national standards provides a useful way for helping teachers to identify how each space imagery activity can fit within their local curriculum, and this feature has been well received by teachers. Each of the CASDE activities are very technology-intensive, and thus fit within national efforts to enhance the technology literacy of both teachers and students

CASDE has found that space imagery can represent a powerful and motivating tool for learning, by encouraging active involvement in real life science activities and problems. By examining space imagery, students "see the world" in new ways, and space imagery becomes an educational "hook" for both students and teachers.

Learn more about CASDE at <http://www.casde.unl.edu/casde.html> and DataSlate at <http://casde.jpl.nasa.gov/dataslate/>. ■

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PlanetFest'99 - Exploring Mars, Jupiter, and Beyond

This past December the Planetary Society hosted 1999's annual PlanetFest event in Pasadena, California. Using the latest Internet technology, PlanetFest '99 reached across the globe to bring international participation to a variety of convention activities, providing accessibility to many of the presentations, panels, and debates by leading scientists participating in the New Millennium Symposium. Additionally, the Galileo Mission presented its Grand Finale, flying close by Jupiter's volcanic moon Io and Mars Polar Lander touched down in an unexplored region of Mars.

The 99 PlanetFest hosted many distinguished guest speakers, an exhibition arena, and the ever popular "Childs Universe,"a hands-on, interactive experience with events, displays, and exhibits that enables children and their families to discover the wonder and ways of science and space exploration.

Exhibition - "The Excitement of Exploration"

PlanetFest '99 was again the site for some of the most eye-opening exhibits about humankind's exploration of the universe, offering the excitement of new discoveries from the Galileo mission, as well as insights into the broad range of human exploration. The displays included current and future planetary missions and exhibits of telescopes, educational resources, CD-ROMS, and more.

The Exploring Distant Worlds Book Extravaganza featured classic and just-released science and science fiction books for all ages. The Extravaganza, "a tour of the creative and inventive mind as it tries to understand our universe," featured such authors as Ray Bradbury, David Brin, and Kim Stanley Robinson. Authors were available throughout each day to discuss and sign their works.

During the 'Fest the award-winning artist, Michael Carroll put the final touches on his original painting, "From Longships to Spaceships." This massive mural depicts exploration for the last 1,000 years, from excursions on foot, horseback, and covered wagons through rockets, satellites, and spacecraft — ending with the Mars Polar Lander.

The Next Millennium Theatre presented some of the most memorable science and science fiction programs. These included some of Carl Sagan's original Cosmos episodes as well as some of the old-fashioned science-fiction classics that have shaped our perspectives of space exploration.

A Child's Universe

This family-friendly area of PlanetFest creates a universe where children and their parents can experience firsthand the wonders of space exploration. During this 'Fest, activities ranged from creating a tornado in a bottle to making comets to creating an edible planetary rover - all designed to show that science is fun! Speakers such as Bill Nye the Science

Guy addressed science and planetary exploration in ways that entertain and educate children and adults.

The Child's Universe adventures included:

- Meet Bill Nye the Science Guy
- Visit the Mars Machine — a full-scale, detailed model of a Mars Lander
- Experience the latest triumphs in planetary exploration - new sounds and images at every turn
- eight activities about the nature of sound
- Red Rover, Red Rover, a hands-on activity to drive a remote-control rover made out of LEGOs over simulated Mars terrain

The Thomas O. Paine Award

The Thomas O. Paine Award for the Advancement of Human Exploration of Mars was presented posthumously to Planetary Society co-founder, Carl Sagan, and was be accepted by Carl's wife, Ann Druyan. Tom Paine was a former NASA Administrator and Chairman of the President's National Commission on Space. He was also Director of the The Planetary Society until his death. Dr. Paine was a visionary who forsesaw and developed plans for martian exploration and colonization in the 21st century.

The Planetary Society has established a memorial award in his honor for the outstanding individual or group who advances the human exploration of Mars. Past recipients include NASA Administrator Dan Goldin; planetary scientist, Christopher McKay; the Apollo-Soyuz crew; and the Mars Global Surveyor and Mars Pathfinder teams.

The Planetary Society is a nonprofit, nongovernmental organization.

Learn more about the Planetary Society at <http://www.planetary.org> or Michael Carroll's Space Art links at <http://planetary.org/library/gsp-art-carroll.html>

Guest speakers list

Distinguished guests appearing at The Pasadena Center:

- Buzz Aldrin, Planetfest '99 Co-Chairman, astronaut
- Athena Andreadis, Neurobiologist
- Greg Bear, author
- Doug Beason, author & physicist
- Gregory Benford, author & physicist
- Richard Berendzen, The Planetary Society advisory council, historian & astronomer
- Jim Benson
- Dan Barry, Shuttle astronaut
- Jacques Blamont, Centre National d'Etudes Spatial, France (French Space Agency)
- Roger Bonnet, head of European Space Agency Space Science
- Tycho Brahe, astronomer of the past
- Vance Brand, astronaut, Apollo-Soyuz
- David Brin, author
- Caltech Team, undergraduates from Mars Society at Caltech
- Scott Carpenter, astronaut
- Michael Carroll, artist
- Andrew Chaikin, author
- Franklin Chang-Diaz, shuttle astronaut
- Phil Christensen, planetary scientist, Arizona State University
- Richard Cook, Mars Surveyor Operations Project Manager
- Marcello Coradini, head of the Planetary Program, European Space Agency
- Keay Davidson, science writer for the San Francisco Examiner
- Laura Danly, astronomer
- Simonetta DiPippo, Italian Space Agency
- Steven Dick,scientist, US Naval Observatory
- Ann Druyan, author, member of The Planetary Society's board of directors
- Dan Durda, planetary scientist, Southwest Research Institute
- Robert Forward, author and physicist
- Alan Dean Foster, author
- Louis Friedman, Executive Director, The Planetary Society
- Everett Gibson, Jr., NASA/Johnson Space Center
- Mel Gilden, author
- Bill Hartmann, astronomer, author, artist
- Caroline Herschel, astronomer of the past
- Tom Jacobson, producer, Touchstone Pictures' Mission to Mars movie
- Warren James, Hour 25 host
- Charley Kohlhase, former mission manager,Cassini Project
- Stephen Krashen, professor of education, USC
- Ed Krupp, Director, Griffith Observatory
- Laurie Leshin, scientist
- Don L. Lind, astronaut
- John Logsdon, The Planetary Society Board of Directors
- Jon Lomberg, artist
- Rosaly M.C. Lopes-Gautier, Galileo NIMS Team
- Percival Lowell, astronomer of the past
- Hans Mark, The Planetary Society Advisory Council, Under Secretary of Defense, former Associate Administrator of NASA
- Yasunori Matogawa, ISAS, Japan
- Daniel McCleese, Mars Project Scientist, JPL
- Tom McDonough, author, The Planetary Society's SETI advisor
- David McKay, Johnson Space Flight Center
- John McNamee, Project Manager, Mars 98
- Sandra C. Miarecki, Travis Air Force Base, California
- Hitoshi Mizutani, head of Planetary Program, ISAS, Japan
- Bruce Murray, President, The Planetary Society, and Professor of Planetary Science and Geology, California Institute of Technology
- Story Musgrave, astronaut
- George D. "Pinky" Nelson, astronaut, educator
- Arnauld Nicogossian, Associate Administrator of Life & Microgravity Science, NASA
- Stacy Nichols, Lowell Observatory
- Larry Niven, author
- Bill Nye, The Science Guy, Planetfest '99 Co-Chairman
- Adriana Ocampo, The Planetary Society Advisory Council, NASA Headquarters
- Jerry O'Connell, actor, Touchstone Pictures' Mission to Mars movie
- Mike & Denise Okuda, artists, Star Trek
- David Paige, JPL Mars Polar Lander mission
- Robert Picardo, The Planetary Society Advisory Council, actor ("Doctor" on Star Trek Voyager)
- Carl Pilcher, NASA
- Carolyn Porco, University of Arizona

- Jerry Pournelle , author
- Sally Ride, astronaut, first U.S. woman in space
- Rex Ridenoure, Chief Mission Architect
- Kim Stanley Robinson, author
- F. Rochard, Centre National d'Etudes Spatial, France (French Space Agency)
- Tim Rodriquez, Lowell Observatory
- Roald Sagdeev, Planetary Society Board of Directors, Former Head of Russian Space Research Institute
- Kevin Schindler, Lowell Observatory
- Donna Shirley, former head of Mars Program at JPL
- Richard Shiope, JPL
- Gary Sinise, actor, Touchstone Pictures' Mission to Mars movie
- Peter Smith, Mars Pathfinder pictures, head of imaging team at • University of Arizona
- Suzanne Smrekar, lead microprobes scientist on Mars Polar Lander
- Rick Sternbach, artist, Star Trek
- Edward Stone, Director, JPL
- Kathy Sullivan, astronaut, Board of Directors
- Michelle Thaller, astrophysicist, California Institute of Technology
- Neil Tyson, Director, Hayden Planetarium, and Planetary Society Board of Directors
- Dan Werthimer, SETI scientist, UC Berkeley
- Robert Zubrin, Scientist, author
- Richard Zurek, Project Scientist, Mars 98 mission

Webcast Only

- Kevin Anderson, author of forthcoming prequel to Dune.
- Arthur C. Clarke, author of 2001: A Space Odyssey, among many other book.
- Ann C. Crispin, science fiction author
- Philip Morrison, SETI scientist, professor emeritus, MIT
- Joseph Rothenberg, Associate Administrator for Space Flight at NASA (shuttle, space station and future human exploration) ■

NASA's wealth of technology is being re-used in the fields of medicine, industry, education, and by the military to develop products and processes that benefit many sectors of our society. Spinoff applications from NASA's research and development programs are our dividends on the national investment in aerospace.

NASA Spaceborne Technology Tracks Hurricane's Impact on Marine Food Chain

Using spaceborne technologies to study the effects of last fall's Hurricane Floyd, a NASA oceanographer saw indications that there may be significant impacts on the marine food chain along the North Carolina coast due to the extensive rainfall in the region in the aftermath. Because record-breaking rains continued to soak the area, mountains of sediment and waste were washed into the water system. The result was that rivers and tributaries along the Atlantic became choked and major ecological changes began happening, according to Gene Feldman of Goddard Space Flight Center (GSFC).

"Periodically, levels of dissolved oxygen in the water have dropped dramatically as organic matter decomposes, and aquatic life has been threatened in dozens of estuaries and peripheral habitats, commonly referred to as 'dead zones.' The current changes in the area may have lasting repercussions for hundreds of thousands of people," Feldman explained.

Since Floyd hit the region, scientists have been studying the effect on algae blooms and phytoplankton, important links in the regional marine food chain. Their data also will help them understand how the hurricane's aftermath may affect the fragile environment in the coming months. Using data from NASA's Earth-orbiting Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and an airborne laser instrument, scientists from two National Oceanic and Atmospheric Administration (NOAA) centers are monitoring algae growth over large regions, including Pamlico Sound between the North Carolina mainland and the Outer Banks. According to Pat Tester, a NOAA scientist at the Center for Coastal Fisheries and Habitat Research, Beaufort, NC, fertilizer and other nutrients that flowed down the storm flooded rivers in eastern North Carolina are feeding the algae or phytoplankton in the sounds.

"One question is what happens to the aquatic activity in the sounds when this algae dies and begins to starve the waters of oxygen," Tester said. "The long-term observations provided by the NASA technology will help us monitor the phytoplankton in the water."

"The NASA technology improves our ability to monitor these important fishery areas by covering larger areas than

direct sampling from boats can, and by providing this information for weeks or months."

Tester's team is coordinating sampling missions from small boats on the waterways with flights by a NOAA Twin-Otter aircraft carrying the NASA laser and observations from the SeaWiFS spacecraft.

"This approach is providing a three-tier look at the area from space, air and sea," she said.

The laser system, the Airborne Oceanographic Lidar from Goddard's Wallops Flight Facility transmits a green light pulse into the water, where the light is absorbed by the phytoplankton. A receiver on the aircraft detects the green light reflected from the water's surface and red light that is emitted by the chlorophyll pigment in the algae.The SeaWiFS instrument measures changes in water color that indicate where concentrations of phytoplankton are located.

"A spoon in a mixing bowl"

Hurricane Floyd churned North Carolina's coastal waterways like a spoon in a mixing bowl. But, for people who make their home in the region, the flood that began with Floyd was just the beginning. As illustrated in the following images rendered by GSFC's Science Visualization Studio (SVS), the changes to the area since the rainy season began will have lasting repercussions.

September 16, 1999

September 17, 199

September 23, 1999

October 26, 1999

Sedimentation along the coast: LANDSAT.

From space, Landsat 7 captures the massive flow of sedimentation and waste runoff in the area most affected by flooding. Notice the dark coloration in the engorged waterways, indicating heavy concentrations of organic material that's been washed into the water system.

September 23, 1999

September 23, 1999

September 23, 1999

Pamlico river flooding via LANDSAT

In the images above, notice how the Pamlico River swells far past its banks due to heavy rains. The sequence starts with an image prior to the flood taken on July 7th. The second image comes from September 23rd, following Hurricanes Floyd and Irene.

Sedimentation along the coast: SEAWiFS

The Sea Viewing Wide Field of View Sensor, or SEAWiFS, instrument took the following sequence of images over a period of weeks in late summer and early fall. The sequence begins prior to the storm season. The mass of clouds that appears is Hurricane Floyd, grinding into the Carolina coast. Following Floyd, notice how the images show dramatic changes of color in the waterways as they flow towards the ocean. This is particularly visible around Cape Hatteras; the dark mass of water there is sediment trapped by the barrier islands.

SEAWiFS is designed to look at ocean color specifically. In the case of these changes to the coast of North Carolina, the instrument is particularly useful in detecting system wide changes to the environment. SeaWiFS is the scientific portion of the SeaStar satellite, orbiting The Earth at an altitude of 705 kilometers. By providing a regular picture of the planet's color, SeaWiFS helps researchers learn about the state of the world's interconnected ecosystems.

Excerpted from NASA press release 99-126, prepared and approved by Keith Koehler of Wallops Flight Facility and David Steitz, NASA HQ, and the GSFC SVS web site. Images courtesy of SVS.

View additional images and Quicktime movies of the Carolina floods at <http://svs.gsfc.nasa.gov/imagewall/carolina/images.html>. ■

Awards and Special Mention

The American Astronautical Society awarded the 1999 Carl Sagan Award to Dr. Edward Stone, Director of the Jet Propulsion Laboratory, this past November at their National Meeting in Pasadena, California. The award was presented jointly by the American Astronautical Society (AAS) and The Planetary Society. It is presented each year to recognize an individual who has demonstrated leadership in research or policies advancing exploration of the Cosmos. As the recipient, Dr. Stone delivered the third annual Carl Sagan Memorial Lecture following the welcoming and opening remarks.

Be sure to view Dr. Stone's slide presentation "The Role of Robotic Outposts in Establishing a Permanent Presence in Space" at <http://www-sisn.jpl.nasa.gov/ISSUE54/stone.html>.

James Tilton, Applied Information Sciences Branch of Goddard Space Flight Center (GSFC), met with NASA Patent Counsel to file a “Disclosure of Invention and New Technology” form for the hierarchical image segmentation algorithm and its implementation on Multiple Instruction, Multiple Data (MIMD) parallel computers to obtain a United States Patent for NASA technology.

GSFC's Scientific Visualization Studio (SVS) released a host of visuals that were aired by many local and national television stations, including the following: several visuals showing development of the Antarctic ozone hole using Total Ozone Mapping Spectrometer (TOMS) data; SeaWiFS-based flyovers of the Florida Keys using multiple levels of resolution and of Michigan Great Lakes blooms; nine fast turnaround visualizations of Hurricanes Floyd, Dennis, Cindy, and Gert from SeaWiFS, Tropical Rainfall Measuring Mission (TRMM), and Landsat; Vegetation Canopy Lidar visualizations supporting a NASA press release; a SeaWiFs 1999 biosphere visualization; 14 Radarsat-based visualizations of Antarctica; visualizations of TRMM biomass burning supporting a published paper and a NASA press release; and an update of past animations to show the continuation of La Niña conditions. ■